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CROP WEATHER MODELS OF BARLEY AND SPRING WHEAT YIELD FOR AGROPHYSICAL UNITS IN NORTH DAKOTA

3. SHARON LEDUC

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16. Abstract

Models based on multiple regression were developed to estimate barley yield and spring wheat yield from weather data for Agrophysical Units(APU) in North Dakota. The predictor variables are derived from monthly average temperature and monthly total precipitation data at meteorological stations in the cooperative network. The models are similar in form to the previous models developed for Crop Reporting Districts (CRD). The trends and derived variables were the same and the approach to select the significant predictors was similar to that used in developing the CRD models. The APU's were selected to be more homogeneous for crop production than the CRD's. The APU models show slight improvements in some of the statistics of the models, e.g., explained variation. These models will be independently evaluated and compared to the previously evaluated CRD models. The comparison will indicate the preferred model area for this application, i.e., APU or CRD.

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Crop Weather Models of Barley and Spring Wheat Yield for Agrophysical Units in North Dakota

Sharon LeDuc

Previous crop weather models for North Dakota crop reporting districts and the entire state were developed for spring wheat (LeDuc, 1981) and for barley (Motha, 1980). This report documents spring wheat yield models for agrophysical units in North Dakota. Agrophysical units (APU's) are areas defined to be homogeneous with respect to soils and climate, manifested in crop yield. The definition of these areas is contained in a memorandum of understanding from Strommen and Dragg (Jan. 10, 1980). Three APU's or groups of counties, were defined in North Dakota (Figure 1): west (21), central (19) and east (20).

Data

Data were developed for these APU's specifically for use in crop yield modeling efforts. Monthly temperature and precipitation observations for cooperative stations (stations within 5 nautical miles averaged and considered as a single station) were used to estimate the temperature and precipitation appropriate for each county. Counties are the small political subdivisions in Figure 1.

The inverse distance method and the Thiessen method (Linsley, Kohler and Paulhus; 1958), were used for averaging the cooperative weather station data. Both methods used a weighted average of stations within 50 nautical miles of the county's geographic center. This included stations in neighboring states but not from Canada. The number of stations for a county was zero for a few counties in some of the early years but was five for most of the estimates.

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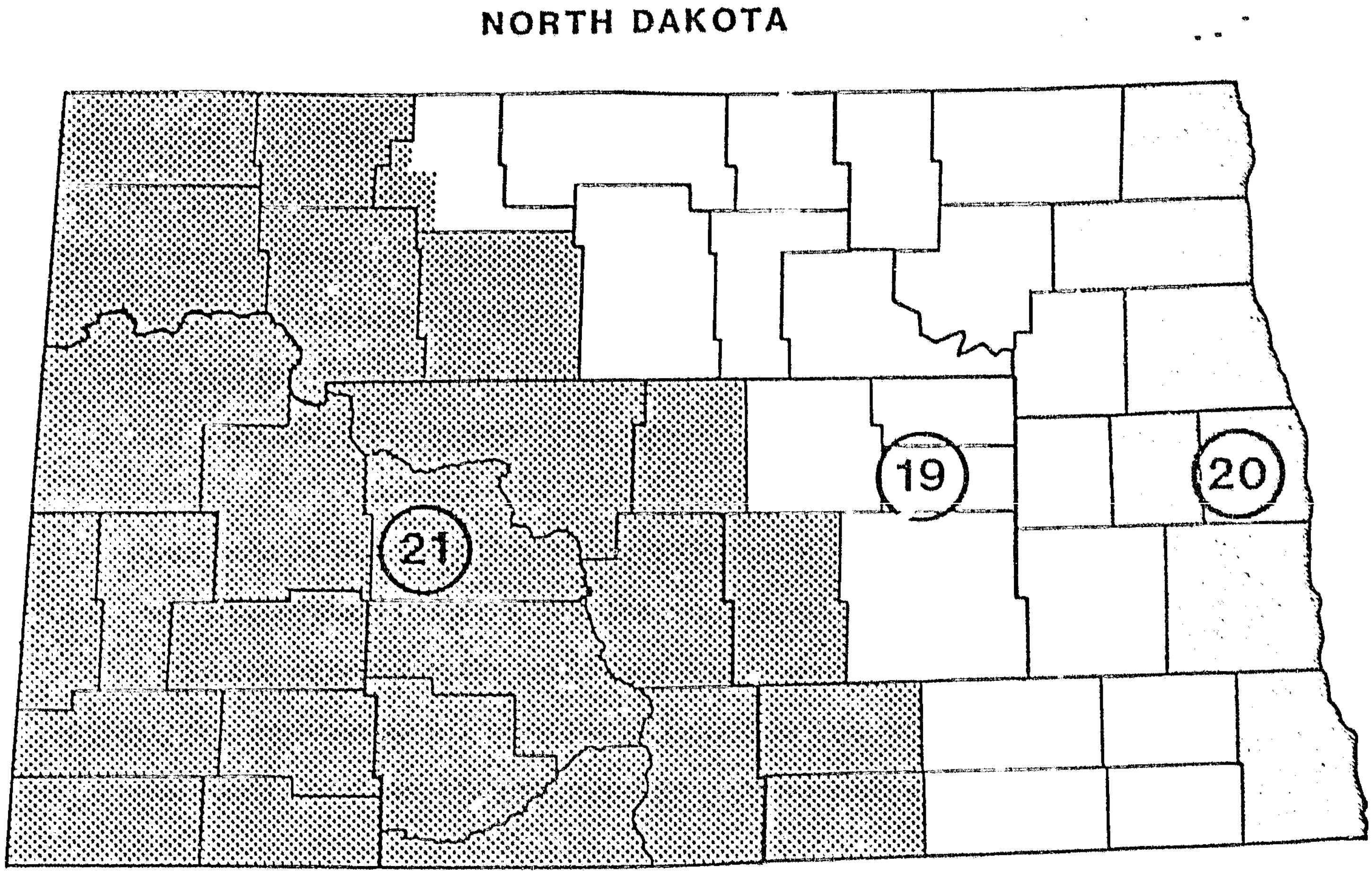
Figure 1.

North Dakota Agrophysical Units (APU's) and Counties



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Each station was weighted accordingly in the averaging. The weight (w_i) for the ith station with the inverse distance method is $w_i = d_i^{-1}$, where d_i is the Euclidean distance from the geometric center of the county to that station. The Thiessen method uses weights based on the area closest to that station (Figure 2). The measure of the area closest to station 3, shown by the lightest shaded area in the county (Figure 2), is the weight assigned to station 3, i.e., $w_3 = A_3$.

This same procedure is used with all three weather variables: maximum temperature, minimum temperature and precipitation. Let V_i represent one of these variables for station i and let station 1, 2, ..., n be all of the stations within fifty nautical miles of the center of the county of interest. The estimate of this variable for this county is:

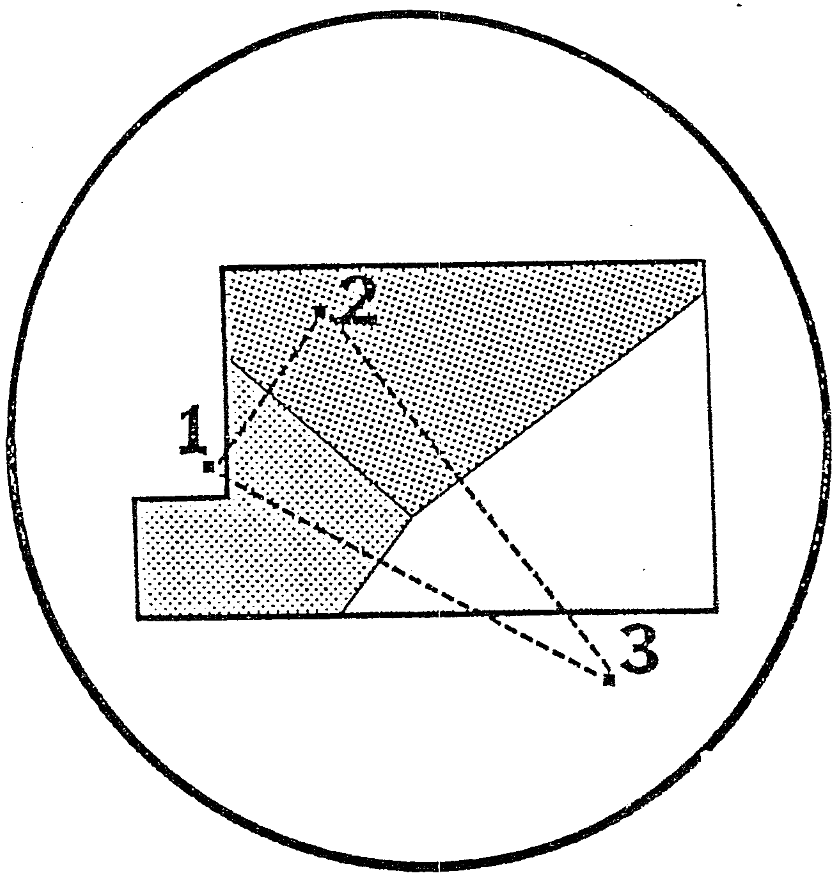
$$V = \sum_{i=1}^{n} w_i V_i / \sum_{i=1}^{n} w_i,$$

where the weight corresponds to one of the two methods. These data were developed under the supervision of Dr. Wayne Decker, Atmospheric Science Department, University of Missouri, Columbia.

The two methods produced similar results. The biggest differences occurred for temperature during the winter, due to frontal movements. These differences were not of concern since the crops are not planted prior to or during the winter. There is no direct physical explanation that would suggest winter temperature should be included in the model. The estimates of weather variables from the inverse distance method were used in the models because the method is much simpler. The counties were assigned to one of the three APU's and the value for a single APU was calculated as the simple average of each meteorological variable for each month of each year. These variables formed the basic data from which the derived variables were calculated.

Figure 2

Thiessen Method of Estimating the Value for an Area from the Value at Several Points



Selection of Variables

Predictor variables were selected from the list of potential predictors described earlier. The method of selection involved the use of stepwise regression. An attempt was made to examine predictor variables selected for a particular APU by the stepwise regression procedure using several selection methods: stepwise, forward and backward. The significance level for entry with the forward selection was .50, the significance level for remaining in the model with backward elimination was .10. Stepwise used the same significance levels. The results of the three methods were compared and variables included by all three methods were considered as potential variables. The maximum R^2 improvement method was used and the model selected for which all variables were significant at the .10 level. Several of these models contained a number of related variables for the same month. Various combinations were tried in an attempt to include information from other months and to reduce the number of variables containing information from the same month. It is not possible to document here all the combinations which were examined nor why many were rejected. The statistical significance in the end of season model was a prime consideration. The need to include information from different periods in the growing season was recognized but not at the expense of including a statistically insignificant variable.

The problem of near collinearity of variables will have to be addressed in the evaluation of the models. Unless the nature of this near collinearity changes, the precision of the predicted value should not be affected (Mandel, 1982). Variables significant for adjacent APU's were checked and included in other APU's if statistically significant and physically meaningful. Variables included in the final model were used for the truncated models, i.e., models

which use only the weather variables for a stated month and the preceding months. These models are used for obtaining estimates within the growing season without making assumptions about future weather conditions. In one case an extra predictor variable was included for May and June truncations but was not in the July final model. The variable plus May precipitation minus potential evapotranspiration was not significant in the model for the end of the season. Variables were considered for inclusion or elimination as a result of comments received from the review of the first draft of this document.
This was the spring wheat model for the western APU. This additional variable improves the earlier truncations but do not add significantly to later truncations.

The estimated coefficients of the squared terms are negative. This is intuitively appealing since extrapolation in either direction should at some poi... associated with a decrease in yields.

Barley Models

The statistics defining the models for various truncations are shown in Table 1. The more important months for estimating the impact of weather on barley yields appear to be June and July. Evapotranspiration appears to be a good indicator of final yield for June in all APU's and also in July for the Central and Western APU's. Temperature in July is important in the Eastern APU. May variables did not seem to be important and there are no truncated models for the month of May. The squared deviation of cumulative precipitation (Sept-Apr) is important in the Central and Eastern APU's. The coefficient is negative indicating that too much or too little precipitation during the fall, winter and spring just prior to planting are two conditions which can be associated with decreased yield.

Table 1

Coefficients and R^2 for Barley Models (Yield in qu/ha)

Coefficients for

Area	Variables Thru	R^2	TREND1	TREND2	DSQ4	ETP6	ETHAT6	ETHAT7	DEF7	XDD7
	Trend	.68	.507	.399						
	April	.78	.491	.502	-.000747					
19	June	.83	.500	.478	-.000496	10.2				
Central	July	.94	.511	.504	-.000295	12.9		-.176	.0337	
	Trend	.80	.359	.558						
	April	.85	.315	.620	-.000364					
20	June	.89	.348	.624	-.000311		-.112			
Eastern	July	.94	.361	.626	-.000227		-.107			-.916
	Trend	.51	.459	.336						
	June	.75	.365	.331		17.3				
21	July	.91	.443	.358		15.7		-.109	1.0586	
Western										

TREND1 is year minus 1930 up to a maximum of 31.

TREND2 is year minus 1960 down to a minimum of 1.

DSQ4 is the squared departure of the Sept thru Apr cumulative precipitation from the APU average (mm).

ETP6 is the ratio of actual to potential evapotranspiration for June (unitless).

ETHAT6, ETHAT7 are the "climatically appropriate" evapotranspirations for June and July, respectively (mm).

DEF7 is precipitation minus the potential evapotranspiration in July (mm).

XDD7 is the July temperature minus the average (°C).

The western APU does not appear to have the problem with excessive precipitation. Extremely hot temperatures and moisture stress at heading, usually in July, are strongly related to yield. Similar variables are found in the models for the separate APU's with the central APU showing similarity to both the eastern and western APU's.

The trend variables selected were the same for each model. As mentioned earlier, the only trend variables considered were those defined by Motha (1980). TREND1 is year minus 1930 until 1961 and is 31 after that. TREND2 is one until 1961 and is year minus 1960 after that.

The coefficients for TREND1 ranged from .315 to .511 for the various models and for TREND2 from .331 to .626. This surrogate for technology indicates the contribution from 1948 to 1981 for the end of the season models are:

central APU, + 16.7 quintals/hectare;

eastern APU, + 17.2 quintals/hectare;

western APU, + 12.9 quintals/hectare.

This corresponds to the fact that larger yield increases have been possible where more moisture is available, i.e., the eastern part of the state. Graphs of the fit of the full season models are shown in Figures 3-5. The standard errors range from 1.60 to 2.49 q/ha for the CRD end of season models which were developed with data from 1931-1978. The standard errors for end of season APU models are 1.36, 1.29 and 1.69 q/ha for the east, central and west, respectively.

Spring Wheat Models

The statistics defining the models for various truncations are shown in Table 2. The multicollinearity problem is obvious in the July truncation for APU 19 and 20. The coefficient for XDD7 has a large negative coefficient and ETHAT7 a large positive coefficient. These effects are offsetting because the two variables are highly correlated.

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Table 2

Coefficients and R^2 for Spring Wheat Models (Yield in qu/ha)

Area	Variables Thru	R^2	TREND1	TREND3	CP4	DSQ4	DEF5	XDD5	XDD6	DEF6	XDD7	ETHAT7	DEF7
	Trend	.72	.884	-.054									
	April	.77	.915	.137		-.000495							
19	June	.80	.939	.134		-.000438			-.579				
Central	July	.89	.903	.424		-.000386			-.510		-678	134	
	Trend	.74	.784	.328									
	April	.79	.795	.453		-.000324							
20	June	.81	.808	.461		-.000292			-.431				
Eastern	July	.89	.763	.738		-.000269			-.400		-322	62	
	Trend	.65	.732										
21	April	.70	.647		.296	-.000156							
Western	May	.82	.653		.0391	-.000549	.0381	1.10					
	June	.85	.642		.0361	-.000407	.0363	0.970		.0239			
	July	.92	.684		.0271	-.000291		.665		.0278	-.46		.0292

TREND1 is 1 until 1956, then is year minus 1954 through 1966 and 12

TREND3 is 1 until 1974, then is year minus 1972;

CP4 is cumulative precipitation (mm) from previous September through April;

DSQ4 is the square of the quantity, CP4 minus the average CP4;

DEF5(DEF6,DEF7) is precipitation minus potential evapotranspiration (mm) for May, June, July);

XDD5, XDD6 (XDD7) is the temperature minus the average temperature for May (June,July) in °C;

ETHAT7 is the climatically appropriate evapotranspiration for July in mm.

May truncation is included for the western APU only while all three APU's have a truncation for April. July, the month of heading, would appear to be the month when weather has the most impact on yield. The explained variation (R^2) increases with the model for the July truncation in comparison to the models for the previous truncation, i.e., June.

The temperature in July is important in the models for all three APU's and the coefficient has a negative sign indicating hotter weather in July is associated with decreases in spring wheat yield across the state. The climatically appropriate evapotransporation is in the model for the central and eastern APU. The western APU includes the precipitation minus potential evapotranspiration. The sign of the coefficients for these variables indicates that more moisture is associated with higher yields.

Cumulative precipitation appears in the models for all APU's. The cumulative precipitation from September prior to planting through April is squared after subtracting the average. This variable has a negative coefficient indicating that too much or too little precipitation during those eight months, which affects soil moisture at planting in April and May, is associated with decreased yield. The western APU also has the linear term of the cumulative precipitation from September through April. This reflects the fact that this APU climatically has less moisture than the other two APU's, and the impact of deficit precipitation is more pronounced, i.e., yields are lower, than with precipitation greater than normal. The western APU model also has a variable for May which indicates yield increases are associated with more precipitation than potential evapotranspiration.

The first trend (TREND1) for the spring wheat models was significant for all APU's and is defined as year minus 1954 from 1955 until 1966. It is one prior to 1955 and 12 after 1966. An additional trend (referred to as TREND3) included in the central and eastern APU's is 1 until 1974, then it is year minus 1972. The changes in the contribution of trend to the yield as estimated from the full season models from 1948 to 1979 are the following: 12.4 quintals/hectare for central APU; 12.5 quintals/hectare for eastern APU; and 7.5 quintals/hectare for western APU. Graphs of the fit of the full season models are shown in Figures 6-8.

Comparison with Crop Reporting District (CRD) Models

Barley

The trend used in the CRD barley models had two linear components, one from 1931 until 1961 and the second from 1961 through 1978. Five of the nine CRDs had an additional quadratic trends from 1961-1978: west central, central, and the three southern CRDs. The APU barley models have two linear trends which by design are exactly the same as the linear trends for the CRD models. No quadratic trends were included in any of the APU models. None of the APU models have May or March truncations. All except two of the CRDs have models for May truncations, and four have a March truncation. Two of the eastern and one of the western CRDs have August truncations whereas only the central APU had an August truncation. The explained variance (R^2) for the full season model is very similar, perhaps slightly higher (.91 - .94) for the APU models; CRD models ranged from .80 to .94. There is quite a bit of difference in the meteorological variables selected as predictors. The July variables did not seem to improve the R^2 as much with the CRD models as with the APU models and August truncations are included for the CRD models.

FIGURE 3 NORTH DAKOTA BARLEY CENTRAL APU 19

PLOT OF YIELD x YEAR SYMBOL USED *

PLOT OF YHAT x YEAR SYMBOL USED .

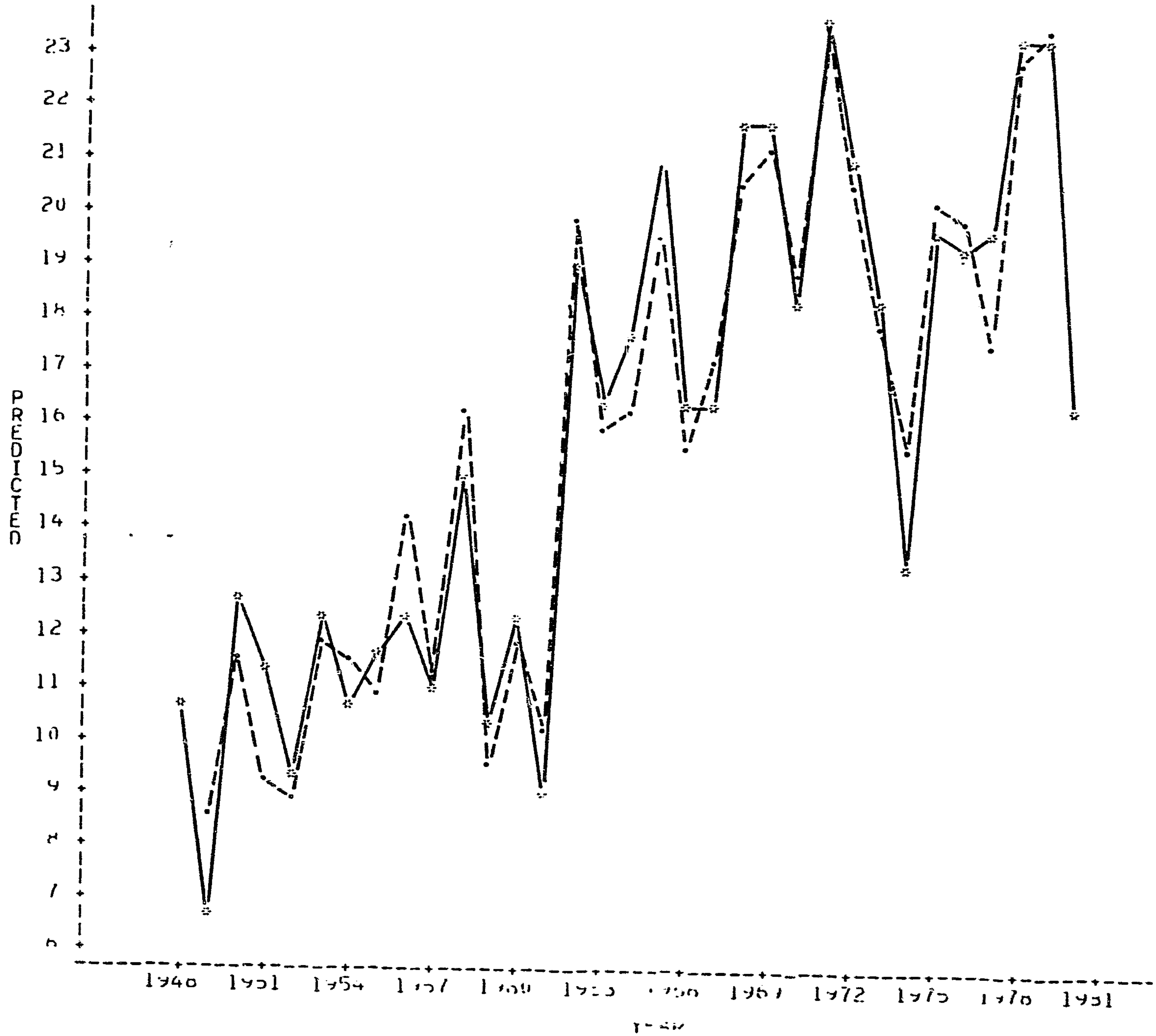

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FIGURE 4 NORTH DAKOTA BARLEY EAS'ERN APU 20

PLOT OF YIELD x YEAR SYMBOL USED *
PLOT OF YHAT x YEAR SYMBOL USED .

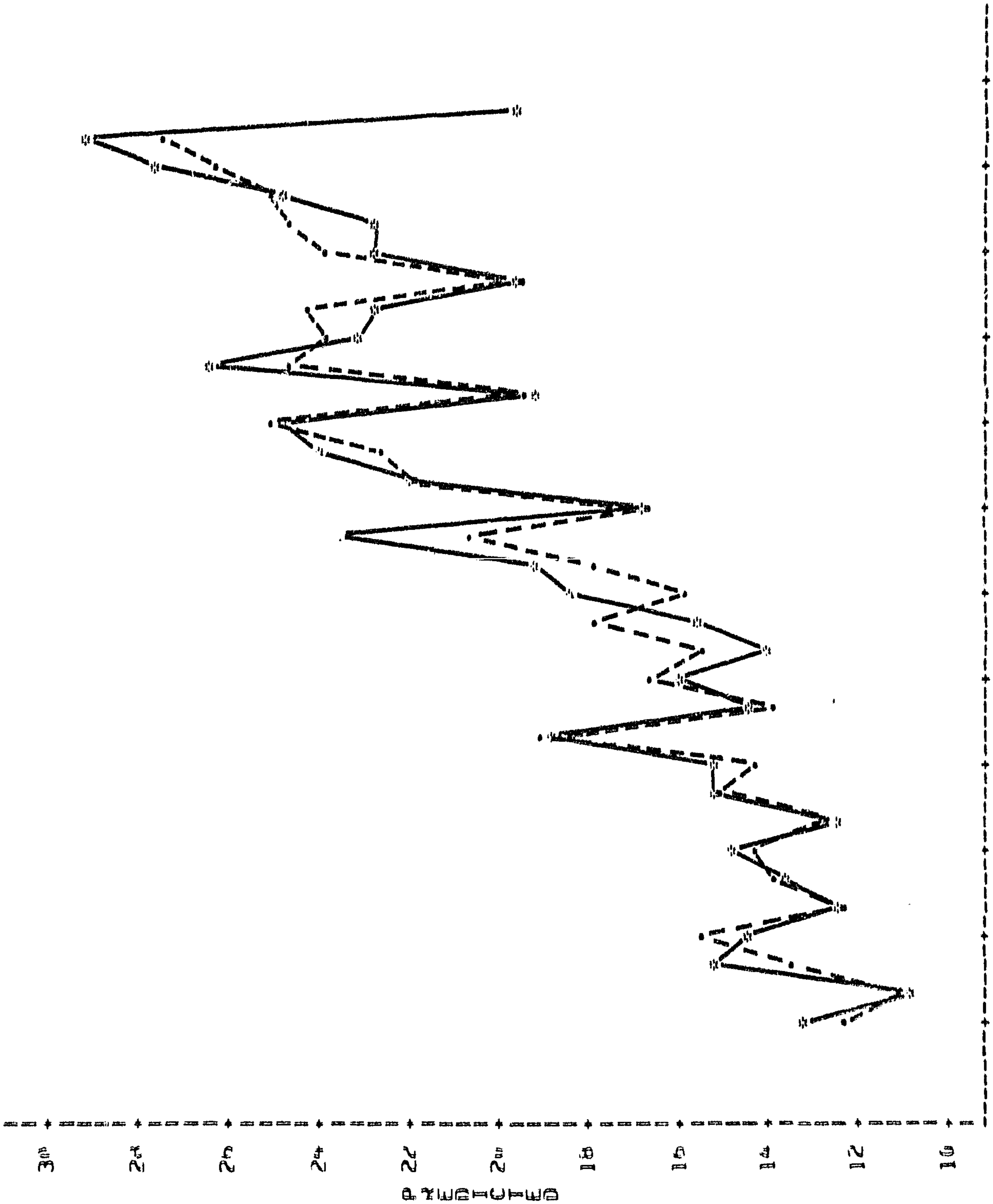

FIGURE 5 NORTH DAKOTA BARLEY WESTERN APU 21

PLOT OF YIELD x YEAR SYMBOL USED *
PLOT OF YHAT YEAR SYMBOL USED -

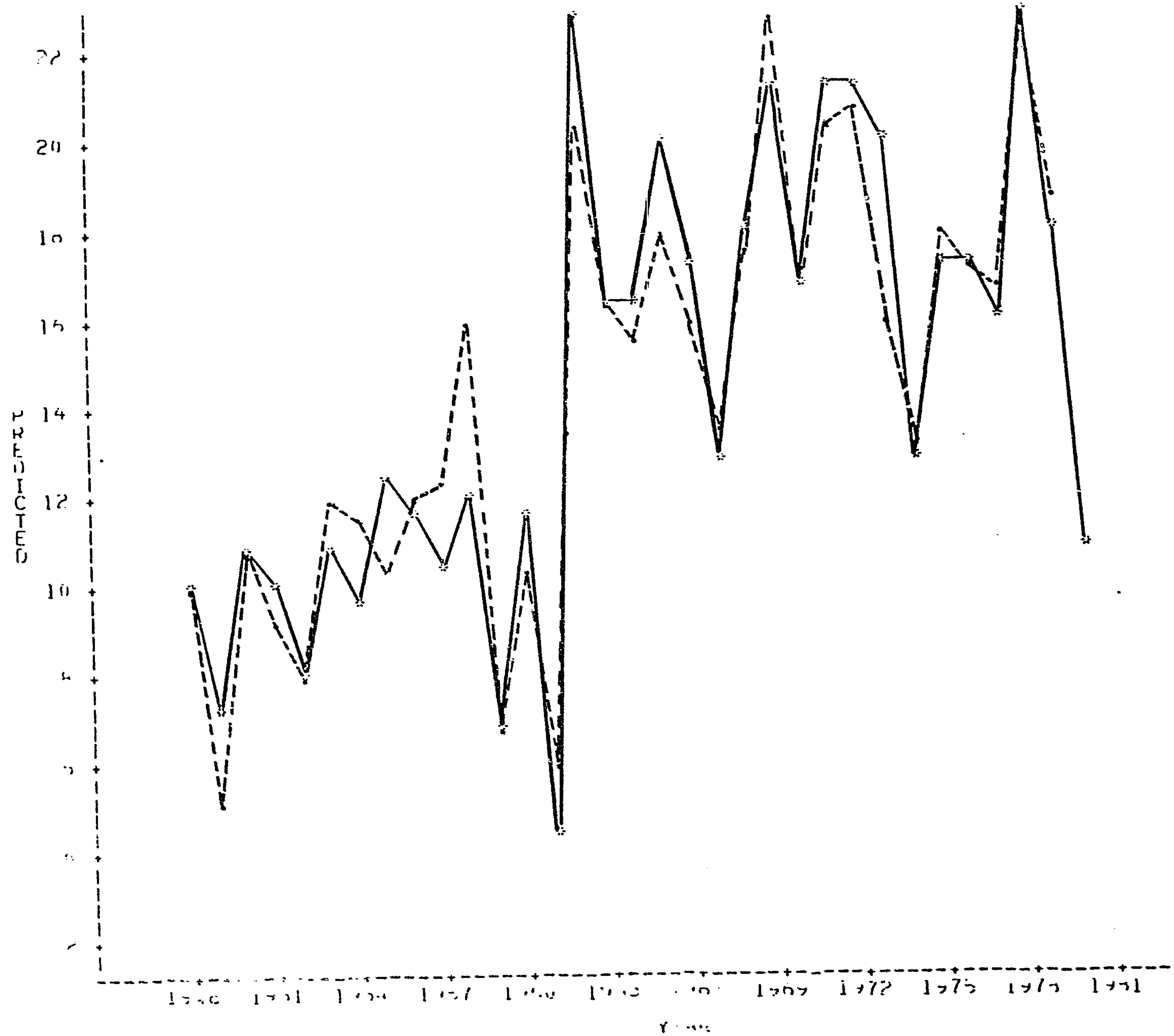

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Figure 6.

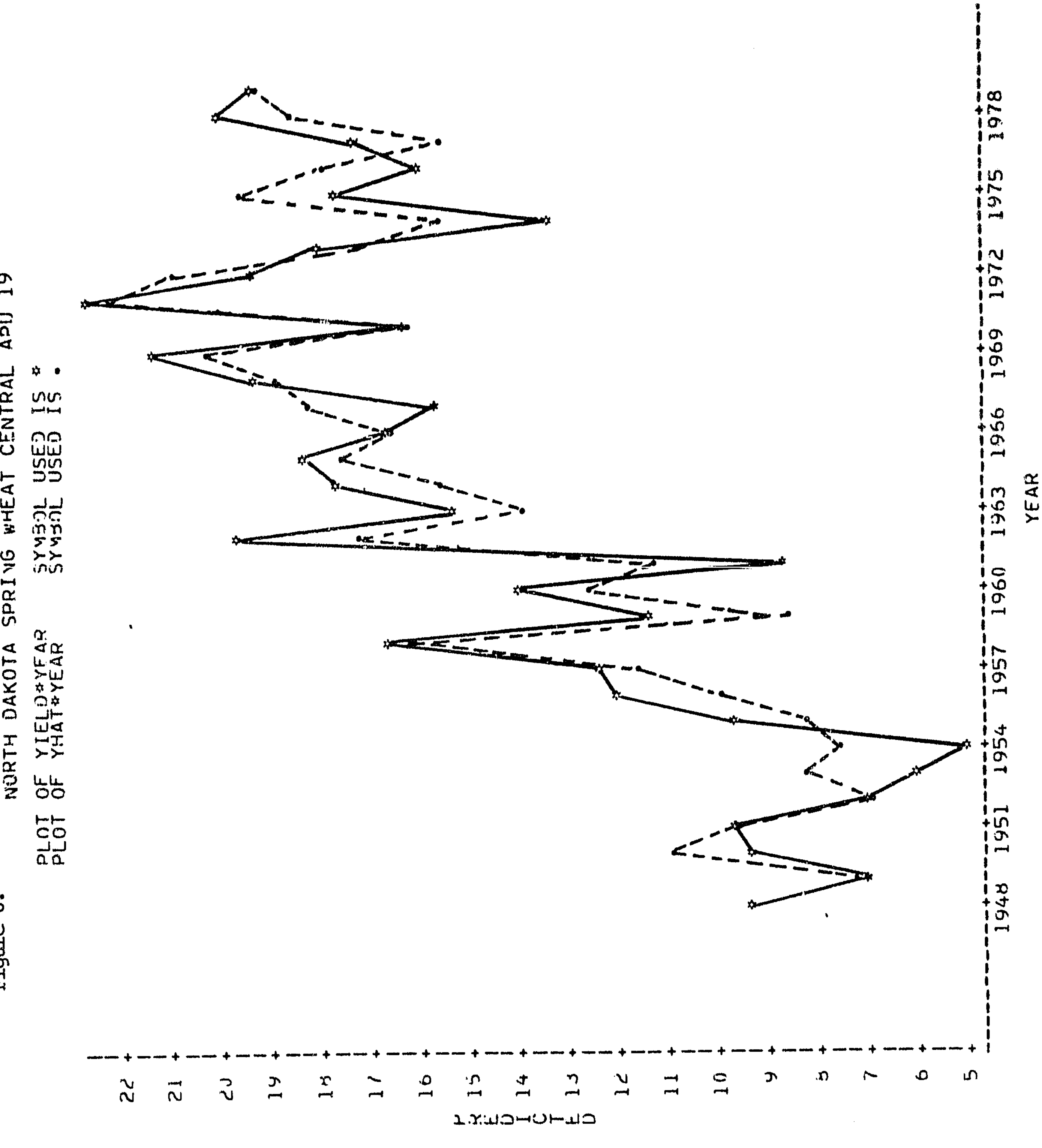


Figure 7. NORTH DAKOTA SPRING WHEAT EASTERN APU 20

PLOT OF YIELD*YEAR SYMBOL USED IS *
PLOT OF YHAT*YEAR SYMBOL USED IS .

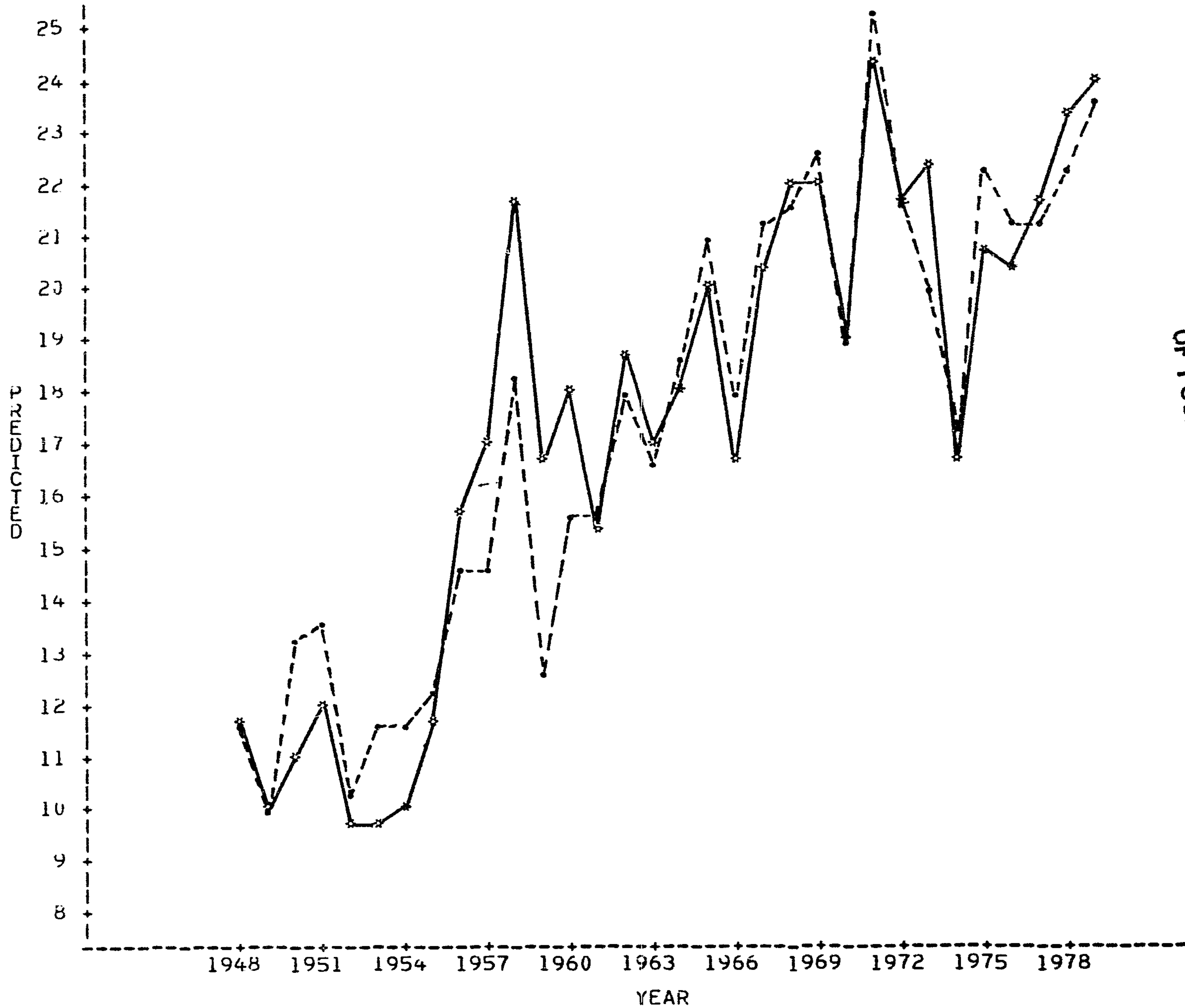
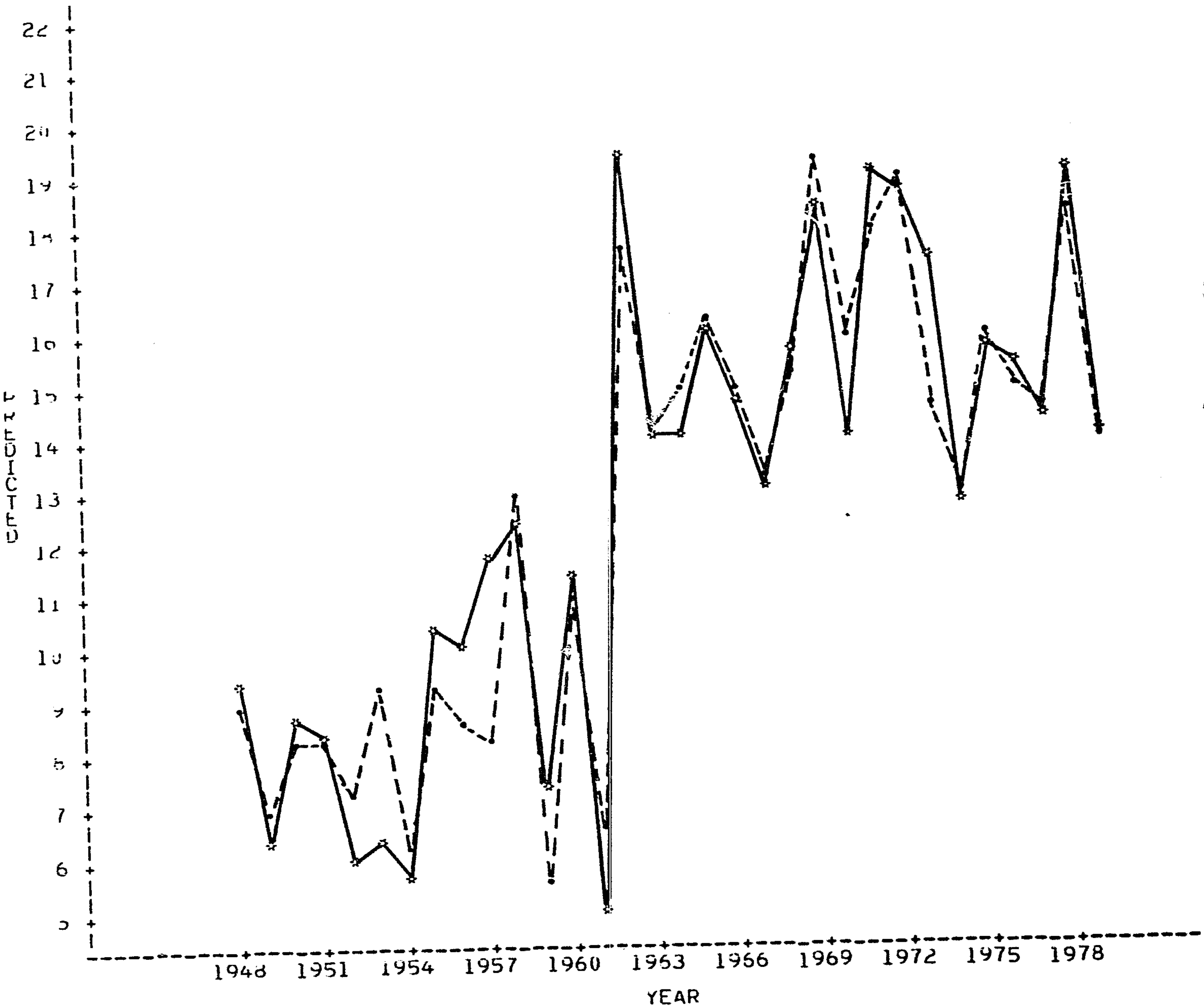


Figure 8. NORTH DAKOTA SPRING WHEAT WESTERN APU 21

PLOT OF YIELD*YEAR SYMBOL USED IS *
PLOT OF YHAT*YEAR SYMBOL USED IS •



Spring Wheat

CRD models included one trend or, in the southeast CRD, two trends. The trends which were examined for APU's were designed to be the same as in the CRD models. The first (TREND1) is linear from 1955 until 1966. The second (TREND2) was linear from 1966 until 1973 and constant before and after that period. The southeast was the only CRD which included the second trend. An additional (TREND3) which was considered but not selected by any of the CRD models was constant prior to 1973 and linear after that. This trend was selected for the eastern and central APU models. All CRDs except the three western and the south central had an August truncation. The explained variance R^2 in yield for the final truncation model, ranged from .85 to .88 for the CRDs, except south central which was .77. The explained variances for APU final truncation models were the following: .89 central APU; .89 eastern APU; and .92 western. These were quite compatible with the CRD results. Although July appeared to be an important month in the APU models, two CRDs (central east and south central) do not even have July truncations and the July truncation does not improve the R^2 appreciably for the southwest CRD. Temperature variables are common for July, the month of heading, for both types of models. Only the three western CRDs and south central CRD have May truncations, correspondingly only the western APU model has a May truncation.

SUMMARY

The models for APUs should provide yield estimates that allow for evaluation of the improvement over CRD models. The models are defined in this paper and a general comparison is made with the CRD models. A testing procedure will be necessary to evaluate the improvement by using APU instead of CRD models.

This study provides the first attempt to develop agrophysical unit models, i.e. models for areas larger than CRDs that are assumed to have similar physical characteristics. These candidate models will be evaluated and compared with the CRD models at the state level. This is a task in the YMD project. Procedures for comparing the yield indications at the state level already exist.

References

Cotter, James., "Data Base Documentation for Iowa Corn and Soybeans and North Dakota Spring Wheat and Barley," Document Number D0033, Modeling Center, Federal Building, Room 200, Columbia, MO 65201, February 12, 1981.

LeDuc, Sharon, "Spring Wheat Models for North Dakota and Minnesota," NOAA/Center for Environmental Assessment Services/Models Branch, Federal Building, Room 200, Columbia, MO 65201, March, 1981.

Linsley, R.K. Jr., M. A. Kohler, and J.L.H. Paulhus, Hydrology for Engineers, New York, McGraw-Hill Book Company, Inc.: 1958, pp. 34-7.

Mandel, John, "Use of Singular Value Decomposition in Regression Analysis," The American Statistician, 36: 15-24, 1982.

Motha, Raymond P., "Barley Models for North Dakota and Minnesota," AgRISTARS, Task 9, Major Program Element #2, NOAA/Center for Environmental Assessment Services/Models Branch, Federal Building, Room 200, Columbia, MO 65201, May, 1980.

Palmer, W.C., "Meteorological Drought", U.S. Department of Commerce, Weather Bureau Research Paper No. 45, 58 pp., 1965.

Strommen, N.D. and J.L. Dragg, AgRISTARS "Mutually (FCPF and YMD) Determined Strata Boundaries for North Dakota and Iowa Pilot Area, Yield and Crop Production Tests," memorandum of understanding, Jan. 10, 1980.

Thornthwaite, C.W., "An Approach Toward a Rational Classification of Climate," Geographical Review, 38:55-94, 1948.

APPENDIX

VARIABLE DEFINITIONS FOR NORTH DAKOTA BARLEY AND SPRING WHEAT

```
TREND1 - 1 IF YR<1955 OR YR-1954 IF YR<1955 OR 12 IF YR<1973 (SP WHEAT)
TREND3 - 1<1973 OR YEAR-1972 IF YEAR>1972 (SP WHEAT)
TREND1 - YR-1930 IF YR<1951 OR 31 IF YR>1950 (BARLEY)
TREND2 - 1 IF YR<1951 OR YR-1950 IF YR>1950 (BARLEY)
CP4 - CUMULATIVE PRECIPITATION FOR APRIL
DSQ4 - SQUARED CUM PRECIP DEVIATION FOR APRIL
DEF5 - PCP-PET FOR MAY
XDD5 - TEMPERATURE DEVIATION FOR MAY
DEF6 - TEMPERATURE DEVIATION-PET FOR JULY
XDD6 - TEMPERATURE DEVIATION FOR JUNE
ETHAT5 - CLIMATICALLY APPROPRIATE POTENTIAL
         EVAPOTRANSPIRATION FOR JUNE
ETP6 - ET/PET FOR JUNE
DEF7 - TEMPERATURE DEVIATION-PET FOR JULY
XDD7 - TEMP DEVIATION FOR JULY
ETHAT7 - CLIMATICALLY APPROPRIATE POTENTIAL
         EVAPOTRANSPIRATION FOR JULY
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NORTH DAKOTA BARLEY CENTRAL APU 19

MODEL: TREND		SSE	228.485409	F RATIO	29.21
		DFE	28	PROB>F	0.0001
DEP VAR: YIELD		MSE	8.160193	R-SQUARE	0.6760

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	-1.068372	4.401951	-0.2427	0.8100
TREND1	1	0.507354	0.166335	3.0502	0.0050
TREND2	1	0.399085	0.103774	3.8457	0.0006

MODEL: APRIL		SSE	154.518657	F RATIO	32.07
		DFE	27	PROB>F	0.0001
DEP VAR: YIELD		MSE	5.722913	R-SQUARE	0.7809

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	-.0000405362	3.698368	-0.0000	1.0000
TREND1	1	0.490558	0.139375	3.5197	0.0016
TREND2	1	0.501902	0.091490	5.4859	0.0001
DSQ4	1	-0.000746905	0.0002077573	-3.5951	0.0013

MODEL: JUNE		SSE	122.978588	F RATIO	30.77
		DFE	26	PROB>F	0.0001
DEP VAR: YIELD		MSE	4.729957	R-SQUARE	0.8256

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	-9.604923	5.013965	-1.9156	0.0665
TREND1	1	0.500404	0.126766	3.9475	0.0005
TREND2	1	0.478392	0.083672	5.7175	0.0001
DSQ4	1	-0.000495788	0.0002124409	-2.3338	0.0276
ETP6	1	10.244010	3.967065	2.5823	0.0158

MODEL: JULY		SSE	39.762215	F RATIO	66.94
		DFE	24	PROB>F	0.0001
DEP VAR: YIELD		MSE	1.656759	R-SQUARE	0.9436

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	7.075284	4.359200	1.6231	0.1176
TREND1	1	0.511309	0.077420	6.6044	0.0001
TREND2	1	0.503610	0.051982	9.6882	0.0001
DSQ4	1	-0.000295259	0.0001320788	-2.2355	0.0349
ETP6	1	12.884531	2.384486	5.4035	0.0001
ETHAT7	1	-0.175584	0.042329	-4.1504	0.0004
DEF7	1	0.033686	0.009859857	3.4165	0.0023

NORTH DAKOTA BARLEY CENTRAL APU 19

OBS	YEAR	YIELD	TREND1	TREND2	DSQ4	ETP6	ETHAT7	DEF7	YHAT
1	1948	10.8118	18	1	.	0.93965	100.860	-36.36	.
2	1949	6.6328	19	1	835.40	0.81221	99.849	-40.98	8.5898
3	1950	12.6985	20	1	846.62	0.98342	91.271	-76.21	11.6240
4	1951	11.3653	21	1	955.01	0.85820	96.313	-88.13	9.2026
5	1952	9.4075	22	1	2693.94	0.77476	96.818	-57.82	9.0577
6	1953	12.2477	23	1	1017.32	1.00000	96.313	-92.13	11.8990
7	1954	10.6296	24	1	620.17	1.00000	101.872	-84.75	11.7995
8	1955	11.7693	25	1	0.01	0.86586	106.937	-53.70	10.9219
9	1956	12.3711	26	1	436.94	0.89793	91.775	-55.90	14.3070
10	1957	10.9560	27	1	894.20	0.91257	110.995	-65.27	11.1795
11	1958	15.1022	28	1	403.88	0.91572	89.257	-42.45	16.4640
12	1959	10.3725	29	1	4510.85	0.74512	102.378	-90.45	9.6130
13	1960	12.4630	30	1	734.24	0.89930	105.923	-105.31	12.1192
14	1961	9.1396	31	1	2294.72	0.54622	98.333	-66.90	10.2608
15	1962	19.0162	31	2	789.43	0.92496	90.767	10.48	20.0244
16	1963	16.4038	31	3	320.53	0.95107	105.923	-63.31	15.8546
17	1964	17.8145	31	4	894.20	1.00000	104.910	-85.92	16.2356
18	1965	21.0203	31	5	320.53	0.90187	96.313	-9.13	19.7414
19	1966	16.4605	31	6	4501.98	0.95850	108.458	-69.79	15.5630
20	1967	16.4361	31	7	123.14	0.88062	97.323	-102.51	17.2100
21	1968	21.5835	31	8	354.69	1.00000	95.808	-67.43	20.6280
22	1969	21.6913	31	9	629.85	1.00000	95.304	-58.74	21.4348
23	1970	18.4062	31	10	145.33	0.91652	105.416	-66.61	18.9639
24	1971	23.6501	31	11	171.53	1.00000	88.754	-60.76	23.6602
25	1972	20.8796	31	12	2714.07	0.79632	89.257	-61.45	20.6770
26	1973	18.3281	31	13	1840.69	0.70028	96.818	-86.82	18.0182
27	1974	13.1728	31	14	9427.78	0.87557	109.980	-99.88	15.7880
28	1975	19.6928	31	15	259.11	1.00000	109.980	-107.88	20.3325
29	1976	19.4077	31	16	198.72	0.85301	101.366	-122.06	19.9955
30	1977	19.6571	31	17	7903.78	0.62401	101.366	-51.06	17.6653
31	1978	23.3598	31	18	3732.82	0.88919	97.828	-66.20	22.9286
32	1979	23.3536	31	19	1607.75	0.91673	101.366	-68.06	23.7304
33	1980	16.2447	31	20	.	.	.	.	.
34	1981	.	31	21	.	.	.	.	.
35	1982	.	31	22	.	.	.	.	.
36	1983	.	31	23	.	.	.	.	.

NORTH DAKOTA BARLEY EAST [illegible] APU 20

MODEL: TREND		SSE	156.519628	F RATIO	59.16
		DFE	29	PROB>F	0.0001
DEP VAR: YIELD		MSE	5.397229	R-SQUARE	0.8032

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	5.184359	3.176678	1.6321	0.1135
TREND1	1	0.358749	0.122042	2.9396	0.0064
TREND2	1	0.557328	0.083553	5.6763	0.0001

MODEL: APRIL		SSE	115.163134	F RATIO	54.56
		DFE	28	PROB>F	0.0001
DEP VAR: YIELD		MSE	4.148683	R-SQUARE	0.8539

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	6.934125	2.841197	2.4406	0.0212
TREND1	1	0.315441	0.107596	2.9236	0.0068
TREND2	1	0.620123	0.075928	8.1672	0.0001
DSQ4	1	-0.000363691	0.000116686	-3.1189	0.0042

MODEL: JUNE		SSE	87.009068	F RATIO	54.94
		DFE	27	PROB>F	0.0001
DEP VAR: YIELD		MSE	3.222558	R-SQUARE	0.8906

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	17.479094	4.308307	4.0571	0.0004
TREND1	1	0.348003	0.095707	3.6361	0.0012
TREND2	1	0.624165	0.066932	9.3253	0.0001
DSQ4	1	-0.000311122	0.000104277	-2.9844	0.0060
ETHAT6	1	-0.111516	0.037109	-3.0078	0.0056

MODEL: JULY		SSE	46.120484	F RATIO	80.73
		DFE	25	PROB>F	0.0001
DEP VAR: YIELD		MSE	1.850785	R-SQUARE	0.9395

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	16.4355[illegible]	3.272[illegible]37	5.0217	0.0001
TREND1	1	0.361161	0.07255[illegible]	4.9755	0.0001
TREND2	1	0.626453	0.050727	12.3496	0.0001
DSQ4	1	-0.000227292	[illegible]	[illegible]	0.0094
ETHAT6	1	[illegible]07339	[illegible]	-3.[illegible]	[illegible]
XDD7	1	[illegible]	[illegible]	[illegible]	0.0001

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NORTH DAKOTA BARLEY EASTERN APR 20

OBS	YEAR	YIELD	TREND1	TREND2	DS04	FTHAT6	XDD7	YHAT
1	1948	13.1599	18	1	1229.4	99.521	0.2719	12.3519
2	1949	10.6071	19	1	5193.0	106.256	0.2719	11.0892
3	1950	15.0704	20	1	4347.8	102.578	-1.5281	13.6862
4	1951	14.3991	21	1	65.0	88.568	-0.7281	15.7918
5	1952	12.7653	22	1	4233.1	110.558	-0.2281	12.3872
6	1953	13.4409	23	1	2710.5	103.191	-0.4281	14.0684
7	1954	14.6627	24	1	291.1	100.743	0.4719	14.4177
8	1955	12.2531	25	1	844.6	103.803	1.9719	12.9505
9	1956	15.2383	26	1	101.3	119.814	-1.7281	15.1515
10	1957	15.2462	27	1	1448.8	94.033	2.1719	14.4010
11	1958	18.6598	28	1	1758.3	85.542	-1.9281	19.3591
12	1959	14.5028	29	1	4769.6	112.405	0.5719	13.8623
13	1960	16.1872	30	1	98.8	97.689	0.5719	16.8646
14	1961	13.3264	31	1	1554.4	116.105	-0.4281	15.7661
15	1962	15.7288	31	2	4347.8	105.643	-1.4281	17.8649
16	1963	18.4797	31	3	964.9	116.105	1.0719	15.8470
17	1964	19.1244	31	4	1300.5	100.132	1.3719	17.8370
18	1965	23.5697	31	5	24.4	100.743	-1.0281	20.8864
19	1966	16.6282	31	6	7909.9	105.643	1.3719	16.9961
20	1967	21.8595	31	7	0.9	98.300	-0.7281	22.1321
21	1968	24.3251	31	8	122.4	98.910	-0.9281	22.8487
22	1969	24.3149	31	9	3.3	80.113	-0.7281	25.3365
23	1970	19.0920	31	10	1291.5	117.959	1.2719	19.7758
24	1971	26.3487	31	11	9.4	111.173	-2.5281	24.9031
25	1972	23.1517	31	12	4752.4	109.327	-1.7281	23.9168
26	1973	22.9376	31	13	1300.5	107.484	-0.4281	24.3348
27	1974	19.7470	31	14	15860.3	106.256	2.0719	19.4936
28	1975	22.8250	31	15	0.0	103.803	1.9719	24.0798
29	1976	22.9157	31	16	531.9	113.637	0.5719	24.8123
30	1977	24.6493	31	17	4632.5	108.713	0.4719	25.1269
31	1978	27.5447	31	18	5919.4	104.416	-0.2281	26.5633
32	1979	29.2765	31	19	3473.6	102.578	0.2719	27.4849
33	1980	19.6628	31	20	.	.	.	.
34	1981	.	31	21	.	.	.	.
35	1982	.	31	22	.	.	.	.
36	1983	.	31	23	.	.	.	.

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NORTH DAKOTA BARLEY WESTERN CRD 21

MODEL: TREND

DEP VAR: YIELD

SSE	390.966110	F RATIO	14.98
DFE	29	PROB>F	0.0001
MSE	13.481590	R-SQUARE	0.5081

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	-0.604869	5.020944	-0.1205	0.9049
TREND1	1	0.459529	0.192583	2.3824	0.0240
TREND2	1	0.336344	0.132053	2.5470	0.0164

MODEL: JUNE

DEP VAR: YIELD

SSE	200.961443	F RATIO	27.58
DFE	28	PROB>F	0.0001
MSE	7.177194	R-SQUARE	0.7472

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	-13.390789	4.426765	-3.0250	0.0053
TREND1	1	0.386193	0.141454	2.7302	0.0108
TREND2	1	0.330818	0.096357	3.4333	0.0019
ETP6	1	17.310511	3.364381	5.1452	0.0001

MODEL: JULY

DEP VAR: YIELD

SSE	73.956241	F RATIO	50.68
DFE	26	PROB>F	0.0001
MSE	2.844471	R-SQUARE	0.9069

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	2.055687	5.273589	0.3898	0.6999
TREND1	1	0.442914	0.089962	4.9298	0.0001
TREND2	1	0.358115	0.061201	5.8515	0.0001
ETP6	1	15.701157	2.131770	7.3653	0.0001
DEF7	1	0.058643	0.013535	4.3098	0.0002
ETHAT7	1	-0.109524	0.050995	-2.1476	0.0412

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NORTH DAKOTA BARLEY WESTERN APU 21

OBS	YEAR	YIELD	TREND1	TREND2	ETP6	DEF7	ETHAT7	YHAT
1	1948	10.0883	18	1	0.84536	-45.33	100.105	10.0530
2	1949	7.0956	19	1	0.61661	-73.13	102.144	5.0351
3	1950	10.6805	20	1	0.94994	-88.47	91.461	10.9819
4	1951	10.0171	21	1	0.83415	-81.53	98.068	9.2899
5	1952	8.0359	22	1	0.71656	-81.44	96.541	8.0593
6	1953	10.6514	23	1	1.00000	-96.83	97.559	11.9382
7	1954	9.7209	24	1	1.00000	-95.73	106.229	11.4963
8	1955	12.5589	25	1	0.84762	-83.73	106.229	10.2505
9	1956	11.6224	26	1	0.64264	-34.56	92.984	11.8091
10	1957	10.4842	27	1	1.00000	-91.16	112.372	12.4205
11	1958	11.8873	28	1	0.87435	-49.60	87.914	16.0061
12	1959	6.6542	29	1	0.54866	-122.63	104.696	6.7850
13	1960	11.6366	30	1	0.86384	-116.64	109.810	10.3973
14	1961	4.4362	31	1	0.42913	-93.83	102.654	6.1366
15	1962	22.9648	31	2	0.95718	-19.69	89.434	20.5813
16	1963	16.4648	31	3	0.99494	-72.43	106.741	16.5438
17	1964	16.2762	31	4	1.00000	-94.43	106.741	15.6912
18	1965	20.1683	31	5	0.96180	-62.63	99.595	18.0972
19	1966	17.1790	31	6	0.90906	-72.64	109.810	15.9306
20	1967	12.6938	31	7	0.81806	-115.93	99.086	13.4866
21	1968	18.1414	31	8	1.00000	-103.83	97.559	17.5779
22	1969	21.1133	31	9	1.00000	-26.04	95.524	22.7208
23	1970	16.8336	31	10	0.88480	-73.73	106.229	17.3012
24	1971	21.3243	31	11	1.00000	-85.08	90.447	20.5310
25	1972	21.1259	31	12	0.91150	-65.91	87.408	20.9566
26	1973	19.8789	31	13	0.78574	-101.53	98.068	16.0835
27	1974	12.6090	31	14	0.70764	-109.45	111.859	13.2404
28	1975	17.1066	31	15	1.00000	-117.64	109.810	17.9331
29	1976	17.0923	31	16	0.87582	-114.23	103.675	17.2138
30	1977	15.8613	31	17	0.73560	-87.93	104.186	16.8567
31	1978	22.6923	31	18	0.97910	-73.44	96.541	22.7248
32	1979	17.8074	31	19	0.72608	-66.83	102.654	18.8284
33	1980	10.8543	31	20	.	.	.	.
34	1981	.	31	21	.	.	.	.
35	1982	.	31	22	.	.	.	.
36	1983	.	31	23	.	.	.	.

NORTH DAKOTA SPRING WHEAT CENTRAL APU 19

MODEL: TREND		SSE	198.596791	F RATIO	36.36
		DFE	28	PROB>F	0.0001
DEP VAR: YIELD		MSE	7.092743	R-SQUARE	0.7220

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	7.826164	0.953282	8.2097	0.0001
TREND1	1	0.884414	0.111964	7.8991	0.0001
TREND3	1	-0.053504	0.330742	-0.1618	0.8726

MODEL: APRIL		SSE	165.725782	F RATIO	29.79
		DFE	27	PROB>F	0.0001
DEP VAR: YIELD		MSE	6.137992	R-SQUARE	0.7680

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	8.104205	0.894906	9.0559	0.0001
TREND1	1	0.915176	0.105001	8.7159	0.0001
TREND3	1	0.136696	0.318466	0.4292	0.6712
DSQ4	1	-0.000495168	0.000213973	-2.3142	0.0285

MODEL: JUNE		SSE	145.479418	F RATIO	25.42
		DFE	26	PROB>F	0.0001
DEP VAR: YIELD		MSE	5.595362	R-SQUARE	0.7964

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	7.843107	0.865388	9.0631	0.0001
TREND1	1	0.938568	0.101004	9.2924	0.0001
TREND3	1	0.134181	0.304066	0.4413	0.6627
DSQ4	1	-0.000438013	0.0002064937	-2.1212	0.0436
XDD6	1	-0.578713	0.304231	-1.9022	0.0683

MODEL: JULY		SSE	76.194167	F RATIO	33.50
		DFE	24	PROB>F	0.0001
DEP VAR: YIELD		MSE	3.174757	R-SQUARE	0.8933

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	-13332.1	3847.945	-3.4647	0.0020
TREND1	1	0.902953	0.076909	11.7405	0.0001
TREND3	1	0.424076	0.240057	1.7666	0.0900
DSQ4	1	-0.000386322	0.0001600715	-2.4134	0.0238
XDD6	1	-0.509510	0.229793	-2.2173	0.0363
XDD7	1	-678.091443	195.365814	-3.4709	0.0020
ETHAT7	1	133.988787	38.650423	3.4667	0.0020

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NORTH DAKOTA SPRING WHEAT CENTRAL APU 19

YEAR	TREND1	TREND3	DS04	XDD6	XDD7	ETHAT7	YIELD	YHAT	RES
1948	1	1	.	-0.6531	0.2594	100.860	9.3395	.	.
1949	1	1	835.40	0.1469	0.0594	99.849	7.0363	7.2812	-0.2449
1950	1	1	846.62	-0.4531	-1.6406	91.271	9.4517	10.9544	-1.5028
1951	1	1	955.01	-2.7531	-0.6406	96.313	9.6527	9.5875	0.0652
1952	1	1	2693.94	0.6469	-0.5406	96.818	7.0637	7.0152	0.0486
1953	1	1	1017.82	-0.2531	-0.6406	96.313	5.9022	8.2895	-2.3872
1954	1	1	620.17	-0.9531	0.4594	101.872	4.9588	7.7370	-2.7781
1955	1	1	0.01	-0.5531	1.4594	106.937	9.5952	8.2651	1.3301
1956	2	1	436.94	2.6469	-1.5406	91.775	12.0585	10.1187	1.9397
1957	3	1	894.20	-1.4531	2.2594	110.995	12.1837	11.5357	0.6480
1958	4	1	403.88	-2.5531	-2.0406	89.257	16.6714	16.3282	0.3432
1959	5	1	4610.85	1.5469	0.5594	102.378	11.1801	8.5212	2.6589
1960	6	1	734.24	-1.0531	1.2594	105.923	14.0493	12.5445	1.5048
1961	7	1	2294.72	2.4469	-0.2406	98.333	8.6210	11.2522	-2.6311
1962	8	1	789.43	0.2469	-1.7406	90.767	19.5121	17.2733	2.2388
1963	9	1	320.53	1.8469	1.2594	105.923	15.3625	13.9356	1.4269
1964	10	1	894.20	-0.6531	1.0594	104.910	17.6636	15.7378	1.9258
1965	11	1	320.53	-0.4531	-0.6406	96.313	18.3028	17.6903	0.6125
1966	12	1	4501.98	0.1469	1.7594	108.458	16.6816	16.5106	0.1709
1967	12	1	123.14	-0.6531	-0.4406	97.323	15.8202	18.4495	-2.6293
1968	12	1	364.69	-0.8531	-0.7406	95.808	19.3515	18.9628	0.3887
1969	12	1	629.85	-3.6531	-0.8406	95.304	21.2726	20.4845	0.7881
1970	12	1	146.33	2.3469	1.1594	105.416	16.4824	16.3738	0.1086
1971	12	1	171.53	1.0469	-2.1406	88.754	22.6046	22.2023	0.4023
1972	12	1	2714.07	0.7469	-2.0406	89.257	19.2128	20.9780	-1.7652
1973	12	1	1840.69	0.6469	-0.5406	96.818	17.9005	17.2773	0.6233
1974	12	2	9427.78	0.2469	2.0594	109.980	13.3370	15.5076	-2.1706
1975	12	3	259.11	0.1469	2.0594	109.980	17.6653	19.5247	-1.8593
1976	12	4	198.72	1.4469	0.3594	101.366	16.0227	17.9077	-1.8850
1977	12	5	7903.78	0.7469	0.3594	101.366	17.1677	15.7118	1.4559
1978	12	6	3732.82	0.0469	-0.3406	97.828	19.9980	18.6794	1.3186
1979	12	7	1607.75	-0.1531	0.3594	101.366	19.3054	19.4508	-0.1454

MODEL: TREND		SSE	169.684724	F RATIO	42.32
		DFE	29	PROB>F	0.0001
DEP VAR: YIELD		MSE	5.851197	R-SQUARE	0.7448

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	11.038124	0.829293	13.3103	0.0001
TREND1	1	0.783749	0.098759	7.9360	0.0001
TREND3	1	0.328413	0.300299	1.0936	0.2831

MODEL: APRIL		SSE	136.688105	F RATIO	36.07
		DFE	28	PROB>F	0.0001
DEP VAR: YIELD		MSE	4.881718	R-SQUARE	0.7944

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	11.570228	0.784544	14.7458	0.0001
TREND1	1	0.795246	0.090315	8.8052	0.0001
TREND3	1	0.453153	0.278460	1.6274	0.1149
DSQ4	1	-0.000324472	0.000124804	-2.5999	0.0147

MODEL: JUNE		SSE	124.908902	F RATIO	29.18
		DFE	27	PROB>F	0.0001
DEP VAR: YIELD		MSE	4.626256	R-SQUARE	0.8121

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	11.379142	0.773165	14.7175	0.0001
TREND1	1	0.807850	0.088274	9.1516	0.0001
TREND3	1	0.461471	0.271125	1.7021	0.1002
DSQ4	1	-0.00029208	0.0001231788	-2.3712	0.0251
XDD6	1	-0.430986	0.270097	-1.5957	0.1222

MODEL: JULY		SSE	70.498966	F RATIO	35.13
		DFE	25	PROB>F	0.0001
DEP VAR: YIELD		MSE	2.819959	R-SQUARE	0.8940

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	-6287.04	2047.108	-3.0712	0.0051
TREND1	1	0.762966	0.069959	10.9058	0.0001
TREND3	1	0.737618	0.222407	3.3165	0.0028
DSQ4	1	-0.000269422	.00009940996	-2.7102	0.0120
XDD5	1	-0.399663	0.211054	-1.8937	0.0699
XDD7	1	-322.461052	104.557482	-3.0841	0.0049
ETHAT7	1	62.148680	20.200296	3.0766	0.0050

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NORTH DAKOTA SPRING WHEAT EASTERN APU 20

YEAR	TREND1	TREND3	DSQ4	XDD6	XDD7	ETHAT7	YIELD	YHAT	RES
1948	1	1	1229.4	-0.7469	0.2719	102.735	11.7255	11.6244	0.1011
1949	1	1	5193.0	0.3531	0.2719	102.735	9.9444	10.1169	-0.1725
1950	1	1	4347.8	-0.2469	-1.5281	93.439	11.0548	13.2683	-2.2135
1951	1	1	65.0	-2.5469	-0.7281	97.563	12.0866	13.6806	-1.5939
1952	1	1	4233.1	1.0531	-0.2281	100.147	9.7488	10.4639	-0.7151
1953	1	1	2710.5	-0.1469	-0.4281	99.113	9.6070	11.5809	-1.9739
1954	1	1	291.1	-0.5469	0.4719	103.772	9.9213	11.7289	-1.8076
1955	1	1	844.6	-0.0469	1.9719	111.569	11.6940	12.2599	-0.5659
1956	2	1	101.3	2.5531	-1.7281	92.410	15.5308	14.5921	0.9386
1957	3	1	1448.8	-1.6469	2.1719	112.611	16.9172	14.5607	2.3566
1958	4	1	1758.8	-3.0469	-1.9281	91.382	21.6875	18.4946	3.1929
1959	5	1	4769.6	1.3531	0.5719	104.290	16.7743	12.7973	3.9770
1960	6	1	98.8	-1.0469	0.5719	104.290	18.0896	15.7779	2.3117
1961	7	1	1854.4	1.9531	-0.4281	99.113	15.4550	15.5501	-0.0950
1962	8	1	4347.8	0.2531	-1.4281	93.954	18.6284	18.1596	0.4688
1963	9	1	964.9	1.9531	1.0719	106.886	17.0492	16.7123	0.3369
1964	10	1	1300.5	-0.6469	1.3719	108.445	18.0935	18.6012	-0.5077
1965	11	1	24.4	-0.5469	-1.0281	96.015	20.1657	21.0552	-0.8895
1966	12	1	7909.9	0.2531	1.3719	108.445	16.5404	17.9867	-1.4462
1967	12	1	0.9	-0.9469	-0.7281	97.563	20.3968	21.4510	-1.0542
1968	12	1	122.4	-0.8469	-0.9281	96.531	21.9607	21.7220	0.2387
1969	12	1	3.8	-3.9469	-0.7281	97.563	22.0617	22.6492	-0.5875
1970	12	1	1291.5	2.2531	1.2719	107.925	19.1415	18.9007	0.2408
1971	12	1	9.4	1.1531	-2.5281	88.302	24.4461	25.4459	-0.9999
1972	12	1	4752.4	0.8531	-1.7281	92.410	21.6669	21.6481	0.0188
1973	12	1	1300.5	0.5531	-0.4281	99.113	22.4642	20.0736	2.3905
1974	12	2	15660.3	0.3531	2.0719	112.090	16.7706	17.3286	-0.5580
1975	12	3	0.0	-0.0469	1.9719	111.569	20.6040	22.3553	-1.7513
1976	12	4	531.9	1.5531	0.5719	104.290	20.3295	21.4127	-1.0833
1977	12	5	4632.5	0.7531	0.4719	103.772	21.6260	21.3828	0.2432
1978	12	6	5919.4	0.0531	-0.2281	100.147	23.3490	22.4899	0.8590
1979	12	7	3473.6	-0.2469	0.2719	102.735	23.9787	23.6382	0.3404

MODEL: TREND

DEP VAR: YIELD

SSE	203.891653	F RATIO	56.23
DFE	30	PROB>F	0.0001
MSE	6.796388	R-SQUARE	0.6521

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	7.104685	0.867359	8.1912	0.0001
TREND1	1	0.731606	0.097565	7.4986	0.0001

MODEL: APRIL

DEP VAR: YIELD

SSE	175.049397	F RATIO	21.91
DFE	28	PROB>F	0.0001
MSE	6.251764	R-SQUARE	0.7013

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	3.322984	1.947307	1.7065	0.0990
TREND1	1	0.647338	0.105244	6.1508	0.0001
CP4	1	0.029568	0.013774	2.1466	0.0406
DSQ4	1	-0.000155576	0.0002088287	-0.7450	0.4625

MODEL: MAY

DEP VAR: YIELD

SSE	105.230415	F RATIO	23.76
DFE	25	PROB>F	0.0001
MSE	4.047324	R-SQUARE	0.8204

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	3.037801	1.687983	1.7997	0.0835
TREND1	1	0.652802	0.084770	7.7009	0.0001
CP4	1	0.039064	0.011628	3.3594	0.0024
DSQ4	1	-0.000548538	0.0001928312	-2.8447	0.0086
DEF5	1	0.038111	0.013695	2.7827	0.0099
XDD5	1	1.098873	0.272661	4.0302	0.0004

MODEL: JUNE

DEP VAR: YIELD

SSE	88.616688	F RATIO	23.39
DFE	25	PROB>F	0.0001
MSE	3.544676	R-SQUARE	0.8488

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	4.021538	1.643747	2.4466	0.0218
TREND1	1	0.642444	0.079476	8.0835	0.0001
CP4	1	0.036093	0.010969	3.2906	0.0030
DSQ4	1	-0.000406654	0.0001919924	-2.1181	0.0443
DEF5	1	0.036329	0.012843	2.8286	0.0091
XDD5	1	0.967387	0.262297	3.6881	0.0011
DEF6	1	0.023880	0.011031	2.1649	0.0401

NORTH DAKOTA SPRING WHEAT WESTERN APU 21

MODEL: JULY	SSE 47.566303	F RATIO	32.55
DEP VAR: YIELD	DFE 23	PROB>F	0.0001
	MSE 2.068100	R-SQUARE	0.9188

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	6.997863	1.616037	4.3303	0.0002
TREND1	1	0.684311	0.061575	11.0955	0.0001
CP4	1	0.028964	0.008559412	3.3839	0.0026
DSQ4	1	-0.000290923	0.0001552915	-1.8734	0.0738
DEF5	1	0.027167	0.010370	2.6198	0.0153
XDD5	1	0.665296	0.223812	2.9726	0.0068
DEF6	1	0.027845	0.008530158	3.2643	0.0034
XDD7	1	-0.461521	0.231920	-1.9900	0.0586
DEF7	1	0.029206	0.013037	2.2403	0.0350

NORTH DAKOTA SPRING WHEAT WESTERN APU 21

YEAR	TREND1	CP4	DSW4	DEF5	XDD5	DEF6	XDD7	DEF7	YIELD	YHAT	RES
1948	1	149	68.1	-43.310	0.7344	-35.028	-0.125	-45.33	9.2279	9.0348	0.1931
1949	1	127	915.1	-41.178	1.8344	-64.919	0.275	-73.13	6.4140	7.1258	-0.7118
1950	1	178	430.6	0.419	-2.4656	-35.340	-1.825	-88.47	8.7770	8.3578	0.4192
1951	1	146	126.6	-49.816	1.0344	-21.949	-0.525	-81.53	8.3155	8.4587	-0.1432
1952	1	139	333.1	-63.147	0.9344	-44.138	-0.825	-81.44	5.8585	7.2905	-1.4321
1953	1	135	495.1	34.894	-1.7656	21.529	-0.625	-96.83	6.4663	9.2788	-2.8125
1954	1	133	588.1	-17.196	-1.7656	-2.532	1.075	-95.73	5.7238	6.3589	-0.6351
1955	1	158	0.6	-24.178	1.8344	-19.591	1.075	-83.73	10.2626	9.3347	0.9278
1956	2	116	1701.6	-12.139	0.0344	-64.929	-1.525	-34.56	9.8675	8.8108	1.0567
1957	3	122	1242.6	-22.473	0.2344	7.409	2.275	-91.16	11.6657	8.2623	3.4034
1958	4	145	150.1	-74.556	2.6344	-14.999	-2.525	-49.60	12.4263	12.9173	-0.4910
1959	5	100	3277.6	-16.841	-1.3656	-55.293	0.775	-122.63	7.2423	5.5174	1.7250
1960	5	166	76.6	-1.140	0.3344	-27.965	1.775	-116.64	11.3341	11.0763	0.2578
1961	7	100	3277.6	-38.483	-0.6656	-96.320	0.375	-93.83	5.0277	6.6472	-1.6195
1962	8	148	85.6	60.523	-0.3656	-32.229	-2.225	-19.69	19.2734	17.6895	1.5839
1963	9	155	76.6	-15.812	-0.4656	-9.522	1.175	-72.43	14.0367	14.2530	-0.2163
1964	10	113	1540.6	-32.495	1.4344	51.907	1.175	-94.43	13.9484	15.0271	-1.0787
1965	11	128	855.6	44.188	-0.4656	-33.782	-0.225	-62.63	16.0259	16.2084	-0.1825
1966	12	152	27.6	-35.477	-0.3656	-17.849	1.775	-72.64	14.7520	14.9592	-0.2072
1967	12	172	217.6	-22.239	-2.3656	-45.591	-0.325	-115.93	13.0115	13.4446	-0.4331
1968	12	151	14.1	-16.898	-2.2656	1.095	-0.625	-103.83	15.5500	15.1886	0.3614
1969	12	153	33.1	-45.810	0.7344	17.098	-1.025	-26.04	18.4113	19.3536	-0.9423
1970	12	173	248.1	18.853	-0.5656	-60.680	1.075	-73.73	14.1135	15.9448	-1.8314
1971	12	188	945.6	-29.812	-0.4656	8.628	-2.025	-85.08	18.9228	17.9500	0.9728
1972	12	250	8502.6	21.514	1.1344	-54.299	-2.625	-65.91	18.6306	19.0615	-0.4309
1973	12	155	5.1	-34.473	-0.0656	-43.919	-0.525	-101.53	17.3279	14.7713	2.5566
1974	12	221	4064.1	28.784	-2.0656	-83.919	2.175	-109.45	12.5954	13.1594	-0.5640
1975	12	203	2093.1	-7.812	-0.4656	11.595	1.775	-117.64	15.7577	16.0261	-0.2684
1976	12	187	885.1	-53.479	0.8344	-27.446	0.575	-114.23	15.3420	15.1048	0.2372
1977	12	90	4522.6	-42.102	4.9344	-38.907	0.675	-87.93	14.2562	14.6767	-0.4206
1978	12	259	10353.1	8.164	1.6344	-30.160	-0.825	-73.44	18.9730	18.4044	0.5686
1979	12	184	715.6	-29.239	-2.3656	-65.990	0.375	-66.83	14.1295	13.9724	0.1571

* U.S. GOVERNMENT PRINTING OFFICE: 1982—569-011/1690